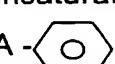


We claim:

1. A method for improving the permeability of a petroleum-containing formation, said method comprising treating said formation with a composition which comprises at least one nonionic surfactant and at least one cationic surfactant in an amount and a concentration effective to improve the permeability of said formation.
- 10 2. The method of claim 1 wherein said at least one nonionic surfactant is selected from the group consisting of alkanolamides, alkoxylated alcohols, alkoxylated amines, alkyl phenyl polyethoxylates, lecithin, hydroxylated lecithin, fatty acid esters, glycerol esters and their ethoxylates, glycol esters and their ethoxylates, esters of propylene glycol, sorbitan, ethoxylated sorbitan 15 polyglycosides and mixtures thereof.
3. The method of claim 2 wherein said at least one nonionic surfactant is an ethoxylated linear or branched alcohol of the formula:

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wherein R is a C<sub>8</sub>-C<sub>30</sub> saturated or unsaturated, branched or straight chain alkyl, or alkylphenyl group of the formula A -  - O(CH<sub>2</sub>CH<sub>2</sub>O)<sub>z</sub>, wherein A is a C<sub>8</sub>-C<sub>30</sub> saturated or unsaturated, branched or straight chain alkyl, preferably a C<sub>9</sub>-C<sub>12</sub> linear or branched alkyl, and z is an integer of from 1 to 30.

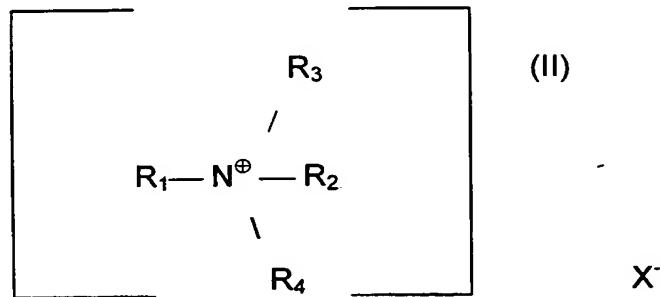
4. The method of claim 3 wherein wherein A is a saturated or unsaturated, branched or straight chain C<sub>9</sub>-C<sub>12</sub> alkyl.

5. The method of claim 3 wherein said ethoxylated alcohol is selected from the group consisting of laury alcohol ethoxylated with 3 moles of ethylene oxide(EO), coco alcohol ethoxylated with 3 moles of EO, stearyl alcohol ethoxylated with 5 moles of EO, mixed C<sub>12</sub>-C<sub>15</sub> alcohol ethoxylated with 7 moles 5 EO, mixed secondary C<sub>11</sub>-C<sub>15</sub> alcohol ethoxylated with 7 moles EO, mixed C<sub>9</sub>-C<sub>11</sub> linear alcohol ethoxylated with 6 moles EO, a C<sub>9</sub>-C<sub>11</sub> alcohol ethoxylated with 4 moles EO, and mixtures thereof.

6. The method of claim 1 wherein said at least one cationic surfactant is 10 selected from the group consisting of primary, secondary and tertiary amines, quaternary ammonium compounds, alkyl pyridinium salts and mixtures thereof.

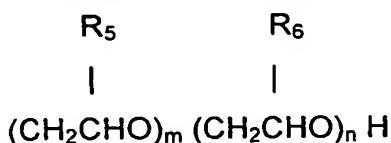
7. The method of claim 6 wherein said at least one cationic surfactant is a quaternary ammonium compound of the general formula:

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wherein R<sub>1</sub> is an saturated or unsaturated, branched or straight chain alkyl group having 8-22 carbon atoms, preferably, cocoalkyl; R<sub>2</sub> is a C<sub>1</sub> to C<sub>6</sub> alkyl group, 2-ethylhexyl, hydroxyethyl, hydroxypropyl, preferably methyl, ethyl or propyl; R<sub>3</sub> is 25 selected from R<sub>1</sub>, R<sub>2</sub> or a group of the formula:

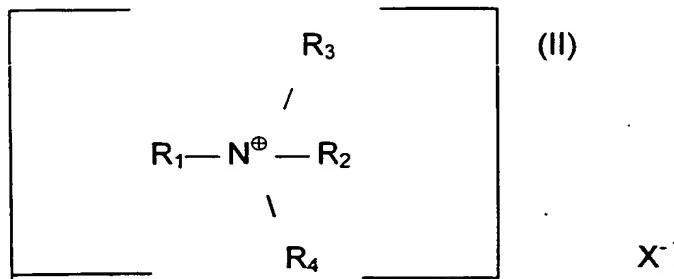


wherein  $R_5$  and  $R_6$  independently selected from hydrogen or a  $C_1$  to  $C_6$  alkyl group, and  $m + n$  is an integer of from 2-80;  $R_4$  is selected from  $R_2$  or  $R_3$ ; and  $X^-$  is an anion.

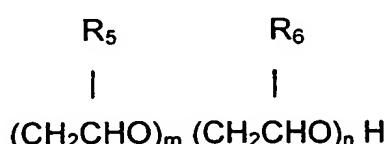
5 8. The method of claim 1 wherein said composition comprises a combination of

- (i) at least one ethoxylated linear or branched alcohol having from 8 to 18 carbon atoms reacted with 2 to 12 moles of ethylene oxide;
  - (ii) at least one quaternary ammonium compound of the general

10 formula:



wherein R<sub>1</sub> is an saturated or unsaturated, branched or straight chain alkyl group having 8-22 carbon atoms, preferably, cocoalkyl; R<sub>2</sub> is a C<sub>1</sub> to C<sub>6</sub> alkyl group, 2-ethylhexyl, hydroxyethyl, hydroxypropyl; R<sub>3</sub> is selected from R<sub>1</sub>, R<sub>2</sub> or a group of the formula:



25 wherein R<sub>5</sub> and R<sub>6</sub> independently selected from hydrogen or a C<sub>1</sub> to C<sub>6</sub> alkyl group, and m + n is an integer of from 2-80; R4 is selected from R<sub>2</sub> or R<sub>3</sub>; and X' is an anion, and

- (iii) up to 30% by weight of at least one (poly) alkyl glucoside.

9. The method of claim 8 wherein said ethoxylated alcohol is selected from the group consisting of lauryl alcohol ethoxylated with 3 moles of ethylene oxide(EO), coco alcohol ethoxylated with 3 moles of EO, stearyl alcohol ethoxylated with 5 moles of EO, mixed C<sub>12</sub>-C<sub>15</sub> alcohol ethoxylated with 7 moles EO, mixed secondary C<sub>11</sub>-C<sub>15</sub> alcohol ethoxylated with 7 moles EO, mixed C<sub>9</sub>-C<sub>11</sub> linear alcohol ethoxylated with 6 moles EO, a C<sub>9</sub>-C<sub>11</sub> alcohol ethoxylated with 4 moles EO, and mixtures thereof.

10. The method of claim 8 wherein  $R_1$  is coco alkyl,  $m+n = 15$ ,  $R_2$  is methyl,  
10  $R_3$  is H and  $X^-$  is  $Cl^-$  or methylsulfate.

11. The method of claim 8 wherein said quaternary ammonium compound is selected from the group consisting of stearyl methyl bis(ethoxy) ammonium chloride (12 moles EO), stearyl ethyl bis(ethoxy) ammonium ethyl sulfate (15 moles EO), tallow methyl bis(ethoxy) ammonium methyl sulfate (15 moles EO), tallow ethyl bis(ethoxy) ammonium methyl sulfate (15 moles EO), hydrogenated tallow methyl bis(ethoxy) ammonium chloride (15 moles EO), coco methyl bis(ethoxy) ammonium chloride (20 moles EO), and mixtures thereof.

20 12. The method of claim 8 wherein the HLB of the quaternary ammonium compound is from about 14.00 to 22.00.

13. The method of claim 8 wherein said composition additionally comprises up to 30% of a (poly) alkyl glycoside of formulae III or IV:

25



wherein R<sub>4</sub> is a straight or branched chain alkyl or alkenyl group having from 8 to 21 carbon atoms, G is a monosaccharide residue and x and y are selected from a number of from 1 to 5;

$R_5$ 

(iv)

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 $R_4 (CHCH_2)_y - O - G_x H$ 

wherein  $R_4$  is a straight or branched chain alkyl or alkenyl group having from 8 to 5 21 carbon atoms,  $R_5$  is hydrogen or a straight or branched chain alkyl or alkenyl group having from 8 to 21 carbon atoms, G is a monosaccharide residue and x and y are selected from a number of from 1 to 5.

14. The method of claim 1 wherein said composition additionally comprises 10 one or more solvents.

15. The method of claim 14 wherein said solvent is selected from the group consisting of water, lower alcohols, glycol ethers and mixtures thereof.

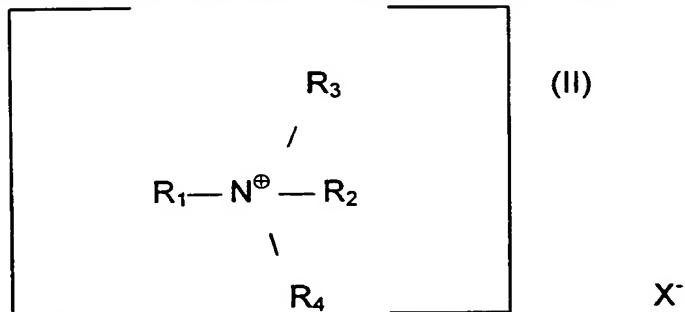
15 16. The method of claim 15 wherein said solvent is selected from the group consisting of methanol, ethanol, 1-propanol, 2-propanol and the like, glycols such as ethylene glycol, propylene glycol, diethylene glycol, dipropylene glycol, polyethylene glycol, polypropylene glycol, polyethylene glycol-polyethylene glycol block copolymers, and mixtures thereof.

20 17. The method of claim 1 wherein the ratio of said at least one nonionic surfactant to said at least one cationic surfactant is in the range of 4:1 to 1:4.

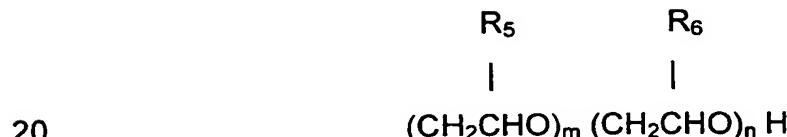
25 18. The method of claim 17 wherein said composition comprising said at least one nonionic surfactant to said at least one cationic surfactant is diluted to a concentration of from about 0.1% to about 10% by weight prior to injection into the formation.

30 19. An aqueous composition for use in restoring the permeability of a subterranean petroleum containing formation which comprises:

- (i) at least one nonionic surfactant which is a ethoxylated linear or branched alcohol having from 8 to 18 carbon atoms reacted with 2 to 12 moles of ethylene oxide;
- (ii) at least one cationic surfactant which is a quaternary ammonium compound of the general formula:



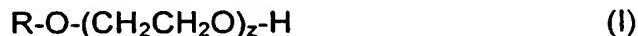
wherein  $R_1$  is an saturated or unsaturated, branched or straight chain alkyl group having 8-22 carbon atoms, preferably, cocoalkyl;  $R_2$  is a  $C_1$  to  $C_6$  alkyl group, 2-ethylhexyl, hydroxyethyl, hydroxypropyl;  $R_3$  is selected from  $R_1$ ,  $R_2$  or a group of the formula:



wherein  $R_5$  and  $R_6$  independently selected from hydrogen or a  $C_1$  to  $C_6$  alkyl group, and  $m + n$  is an integer of from 2-80;  $R_4$  is selected from  $R_2$  or  $R_3$ ; and  $X^-$  is an anion, and

- 25
- (iii) optionally, at least one (poly) alkyl glucoside.

20. The composition of claim 19 wherein said ethoxylated linear or branched alcohol is of the formula:



wherein  $R$  is a  $C_8$ - $C_{30}$  saturated or unsaturated, branched or straight chain alkyl, or alkylphenyl group of the formula  $A - \text{C}_6\text{H}_4 - O(CH_2CH_2O)_z$ , wherein  $A$  is a

C<sub>8</sub>-C<sub>30</sub> saturated or unsaturated, branched or straight chain alkyl, preferably a C<sub>9</sub>-C<sub>12</sub> linear or branched alkyl, and z is an integer of from 1 to 30.

21. The composition of claim 20 wherein wherein A is a saturated or  
5 unsaturated, branched or straight chain C<sub>9</sub>-C<sub>12</sub> alkyl.

22. The composition of claim 20 wherein said ethoxylated alcohol is selected from the group consisting of lauryl alcohol ethoxylated with 3 moles of ethylene oxide(EO), coco alcohol ethoxylated with 3 moles of EO, stearyl alcohol ethoxylated with 5 moles of EO, mixed C<sub>12</sub>-C<sub>15</sub> alcohol ethoxylated with 7 moles EO, mixed secondary C<sub>11</sub>-C<sub>15</sub> alcohol ethoxylated with 7 moles EO, mixed C<sub>9</sub>-C<sub>11</sub> linear alcohol ethoxylated with 6 moles EO, a C<sub>9</sub>-C<sub>11</sub> alcohol ethoxylated with 4 moles EO, 15 mole ethoxylate of coco alkyl amine and mixtures thereof.

15 23. The composition of claim 19 wherein  $R_1$  is coco alkyl,  $m+n = 15$ ,  $R_2$  is methyl,  $R_3$  is H and  $X^-$  is  $Cl^-$  or methylsulfate.

24. The composition of claim 19 wherein said quaternary ammonium compound is selected from the group consisting of stearyl methyl bis(ethoxy) ammonium chloride (12 moles EO), stearyl ethyl bis(ethoxy) ammonium ethyl sulfate (15 moles EO), tallow methyl bis(ethoxy) ammonium methyl sulfate (15 moles EO), tallow ethyl bis(ethoxy) ammonium methyl sulfate (15 moles EO), hydrogenated tallow methyl bis(ethoxy) ammonium chloride (15 moles EO), coco methyl bis (ethoxy) ammonium chloride (20 moles EO), and mixtures thereof.

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25. The composition of claim 19 wherein the HLB of the quaternary ammonium compound is from about 14.00 to 22.00.

26. The composition of claim 19 wherein said composition optionally comprises a (poly) alkyl glycoside of formulae III or IV:

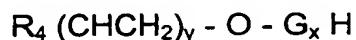


wherein  $R_4$  is a straight or branched chain alkyl or alkenyl group having from 8 to

5 21 carbon atoms, G is a monosaccharide residue and x and y are selected from a number of from 1 to 5;



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wherein  $R_4$  is a straight or branched chain alkyl or alkenyl group having from 8 to 21 carbon atoms,  $R_5$  is hydrogen or a straight or branched chain alkyl or alkenyl group having from 8 to 21 carbon atoms, G is a monosaccharide residue and x and y are selected from a number of from 1 to 5.

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27. The composition of claim 19 wherein said composition additionally comprises one or more solvents selected from the group consisting of water, methanol, ethanol, 1-propanol, 2-propanol and the like, glycols such as ethylene glycol, propylene glycol, diethylene glycol, dipropylene glycol, polyethylene glycol, polypropylene glycol, polyethylene glycol-polyethylene glycol block copolymers, and mixtures thereof.

28. The composition of claim 19 wherein the ratio of said at least one nonionic surfactant to said at least one cationic surfactant is in the range of 4:1 to 1:4.

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29. The composition of claim 19 wherein said composition comprising said at least one nonionic surfactant to said at least one cationic surfactant is diluted to a concentration of from about 0.1% to about 10% by weight prior to injection into the formation.

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